Aug. 29, 1967 P. ABRAMSON ETAL 3,339,022

TRANSISTOR CIRCUIT FOR RECEIVING DATA PULSES

Filed Dec. 16, 1963

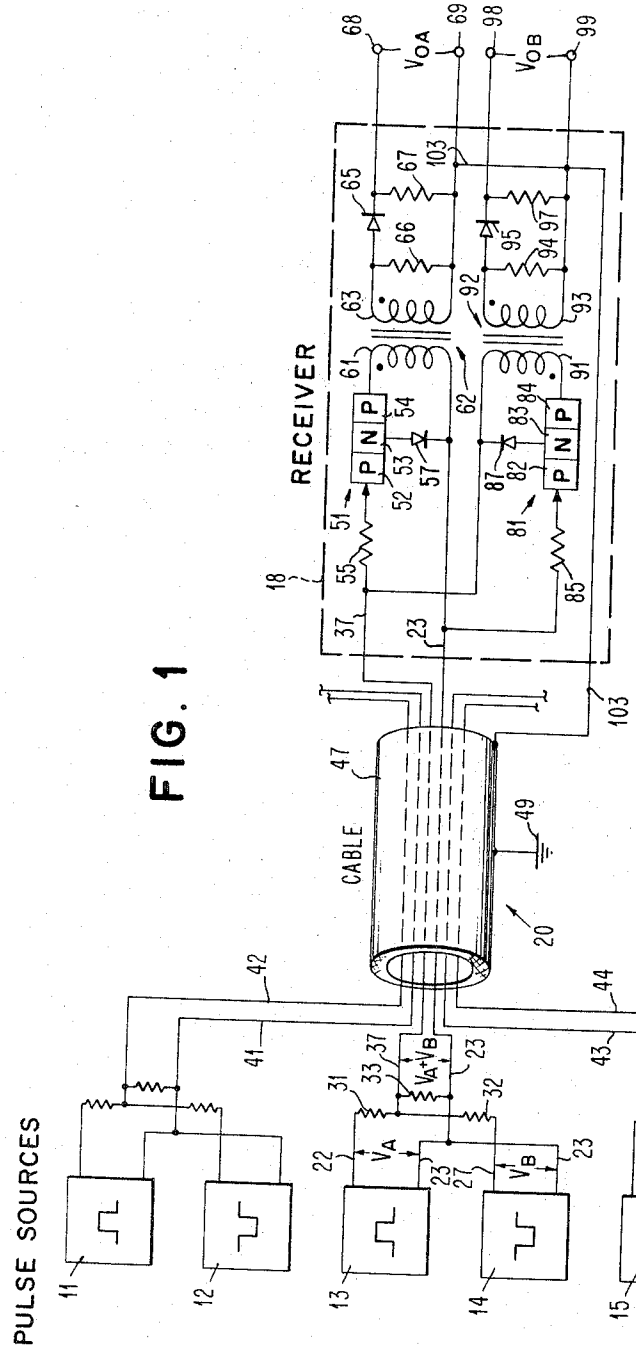

FIG. 1

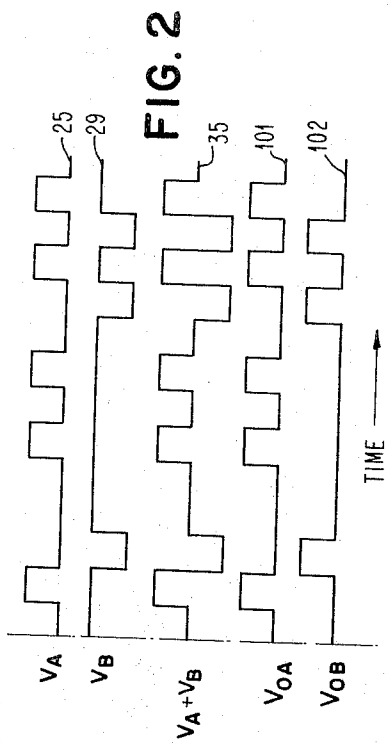

FIG. 2

INVENTORS
PAUL ABRAMSON
GEORGE R. STILWELL, JR.
ALBERT X. WIDMER

BY Edward G. Fiorito
ATTORNEY

United States Patent Office 3,339,022
Patented Aug. 29, 1967

3,339,022

TRANSISTOR CIRCUIT FOR RECEIVING DATA PULSES

Paul Abramson, Yorktown Heights, George R. Stilwell, Jr., West Nyack, and Albert X. Widmer, Peekskill, N.Y., assignors to International Business Machines Corporation, New York, N.Y., a corporation of New York

Filed Dec. 16, 1963, Ser. No. 330,929
11 Claims. (Cl. 178—69)

ABSTRACT OF THE DISCLOSURE

The present circuit is intended for use in systems for transmitting data pulses having a considerable DC component. A twin transformer is used to eliminate "common mode" noise or "cross-talk" induced on a pair of telephone lines by neighboring telephone circuits in a multi-wire cable. The unilateral nature of a transistor is utilized in each line to provide a small time constant for spurious pulses generated by the primary winding when the flux in the transformer collapses. The collector-base reverse impedance of the transistor is large during the generation of these spurious pulses causing the energy to be dissipated rapidly.

This invention relates to data transmission systems, and more particularly to a circuit for receiving data pulses transmitted through a cable containing many neighboring circuits carrying separate data pulses.

A number of problems arise when transmitting data over a plurality of circuits contained in a single cable, such as a telephone cable. Frequently the signals on one telephone circuit induce spurious signals on adjacent circuits resulting in the erroneous transmission of data. These spuriously induced signals are called "cross-talk" or "common mode" noise.

The latter term "common mode" is descriptive of this type of noise because it is induced with equal magnitude on both wires forming a telephone circuit. Therefore the difference in voltage between the pair of telephone wires is unchanged by the "common mode" noise.

One method of eliminating the "common mode" noise on a pair of telephone wires is to connect a transformer on the receiving end of the cable. According to the operation of a transformer, the output voltage represents only the difference in voltage between the pair of telephone wires, rather than the absolute magnitude of the voltage on the individual wires. Therefore the "common-mode" noise induced on both of the wires forming the telephone circuit is not reflected at the output of the transformer.

However, it has been found that undesirable side effects are encountered when using a transformer to eliminate the "common mode" noise from circuits carrying signals in the form of data pulses. The data pulse differs considerably from the usual audio signals. Ordinarily audio signals have no DC (direct current) component, while each data pulse contains a substantial DC component. Further, a number of data pulses may appear in a train causing a substantially continuous DC component to be fed to the transformer.

Considerable difficulty is encountered when data pulses having a DC component are applied to a transformer. The DC component in a data pulse causes the flux in the trannsformer to build up. When the pulse discontinues a rapid collapse of the flux induces a pulse of opposite polarity backward into the telephone circuit. This spurious pulse often causes erroneous operation of the data

transmission system. The problem is even more acute where bi-polar pulses are used in the transmission of data. Here, both positive and negative data pulses are employed on the same pair of telephone wires. Therefore the collapse of the flux in a transformer in response to the application of a positve pulse produces a spurious negative pulse which is sent back into the telephone circuit where it may be misinterpreted as a negative data pulse.

Further, where a train of data pulses are received each having the same DC component, the level of the output voltage from the transformer shifts after a number of pulses are received. The devices utilizing the output of the transformer often employ threshold detectors which require stable signal levels at their inputs. Therefore the shift in signal level at the output of the transformer often causes erroneous operation of such utilization devices, or expensive, complicated modifications are required to compensate for the shift in signal level.

It is an object of the present invention to provide an improved data transmission system.

Still another object of the present invention is to provide an improved data transmission system employing a receiver circuit for eliminating "common mode" noise.

It is another object of the present invention to provide an improved receiver circuit employing a transformer to eliminate "common mode" noise and inhibit the backward flow of spurious pulses from the transformer.

A further object of the present invention is to provide a receiver circuit employing a transformer to eliminate "common mode" noise and capable of receiving a train of data pulses containing a DC component and providing an output signal having a constant signal level.

It is another object of the present invention to provide an improved data transmission system employing bi-polar data pulses.

It is a further object of the present invention to provide an improved circuit for separating bi-polar data pulses.

It is another object of the present invention to provide a receiver circuit capable of eliminating "common mode" noise on a pair of wires carrying bi-polar data pulses.

Still another object of the present invention is to provide an improved receiver circuit employing transformers to eliminate "common mode" noise on a pair of wires carrying bi-polar data pulses.

These and other objects are accomplished in accordance with the present invention by providing a transistor which couples a pair of telephone wires to the primary winding of a transformer. The unilateral nature of the transistor is employed to prevent the backward flow of spurious pulses caused by the collapse of flux in the transformer. This is accomplished by coupling the pair of telephone wires across the emitter and base of the transistor. The primary winding of the transformer is coupled across the collector and base of the transistor. The spurious signals induced by the collapse of the flux in the transformer are met by the high reverse-impedance between the collector and base of the transistor preventing the backward flow of spurious pulses.

In accordance with another aspect of the present invention a second transistor is added similarly connected to a second transformer. The connections are arranged so that when bi-polar pulses are received, one transistor responds to positive pulses while the other responds to negative pulses. Also two diodes are connected to the secondary windings of the transformers. The diodes are oriented so that they pass current in a direction corresponding to the flow of current in the primary winding produced by conduction of the associated transistor.

When the input pulse termminates the flux in the secondary winding of the transformers collapses causing a signal which opposes the forward direction of current flow through the diode. Therefore a high impedance is presented to the secondary windings of the transformers at this time. The high impedance at the secondary windings of the transformers occurs simultaneously with the high impendance at the primary winding of the transformers causing the flux to collapse rapidly. Due to the quick recovery of the transformer between each data pulse received, the output signal level remains constant. Further, the data pulses can be spaced closer together improving the capacity of the data transmission system.

Another advantage of the present invention is that information can be transmitted over each pair of wires in the form of both positive and negative data pulses, thereby increasing the amount of information that can be carried over the pair of wires.

Still another advantage of the present invention is that "common mode" noise is eliminated without the use of any power supplies at the receiver.

Two other advantages are obtained from the use of a transformer in the receiver. First, the telephone cable is isolated and protected from power failures or excess voltages generated by the equipment utilizing the data pulses. Second, with no additional hardware the negative portion of the bi-polar pulses can be inverted so that the two data signals provided by the receiver are in the form of positive uni-polar pulses.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is an electrical schematic illustrating a transmission system embodying the present invention; and

FIG. 2 is a waveform diagram illustrating the voltage levels at various points in the system of FIG. 1.

The data transmission system shown in FIG. 1 illustrates the manner in which the present invention is employed. A group of pulse sources **11–16** is shown at the transmitting end of the system. A receiver **18** is shown at the other end of the system. The data pulses from sources **11–16** are carried through a cable **20**. The receiver **18** operates in response to pulses from sources **13** and **14**. Other receivers, not shown, operate in response to the remaining pulse sources.

As illustrated by the symbol in the pulse source **13**, positive data pulses are provided by source **13**. The pulses appear as a voltage V_A between a pair of lines **22** and **23**. A typical output voltage V_A is illustrated in FIG. 2 by a waveform **25**.

One of the two output lines of pulse source **14** is connected to line **23**. The output of pulse source **14**, labeled V_B in FIG. 1, appears between line **23** and a line **27**. A waveform **29** in FIG. 2 illustrates a typical output from pulse source **14**.

The pulse sources **13** and **14** operate independently and each produce a separate train of uni-polar data pulses. The timing of the pulse sources **13** and **14**, as well as the remaining pulse sources, is arranged so that the positive pulses do not overlap the negative pulses.

The voltages on lines **22** and **27** are mixed by a group of resistors **31–33**. The results of this mixing operation are illustrated by a waveform **35** in FIG. 2. The combined data pulses are represented by the symbols V_A+V_B appearing between line **23** and a line **37**. The mixing resistors **31–33** perform the function of adding the waveforms **25** and **29**. The resulting waveform **35** is in the form of a bi-polar train of data pulses. The positive pulses represent the information generated by pulse source **13**, while the negative portion of the bi-polar waveform **35** represents the independent information generated by pulse source **14**. The waveform **35** does not represent the absolute voltage on either of the lines **23** or **37**; the difference in voltage between lines **23** and **37** is represented.

In the same manner bi-polar pulse trains are generated on another group of lines **41–44**. All of the lines **23**, **37**, and **41–44** are placed together in cable **20**. The cross-section of cable **20** is exaggerated so that the lines contained therein are easily identified in FIG. 1. A shield **47** is shown wrapped about the lines **23**, **37** and **41–44**. The shield **47** is clamped to a reference potential **49**, typically ground.

Due to the close confinement of the lines **23**, **37** and **41–44** within the cable **20**, "common mode" noise is coupled from one line to another. For example the voltage on line **41** induces a signal on the remaining lines **23**, **37** and **42–44**. This induced signal could be readily detected by measuring the voltage difference between the grounded shield **47** and any of the lines **23**, **37** and **42–44**. The magnitude of the induced voltage on any pair of the lines **23**, **37** and **42–44** is approximately the same. Of course the distance from the line **41** effects the magnitude of the signal induced into the neighboring line. However it has been found that the "common mode" noise induced in a pair of lines such as lines **23** and **37** is substantially equal. That is the "common mode" noise induced on lines **23** and **37** when measured with respect to the grounded shield **47**, is substantially equal in magnitude. Therefore the difference in voltage between the lines **37** and **23** remains uneffected by the "common mode" noise.

The receiver **18** performs the function of examining the difference in voltage between the lines **23** and **37** rather than examining the voltage on the individual lines **23** and **37** with respect to a reference potential such as ground **49**. In this manner the "common mode" noise induced on lines **23** and **37** is eliminated.

The receiver **18** includes a PNP type transistor **51** having an emitter electrode **52**, a base electrode **53** and a collector electrode **54**. The line **37** is coupled to the emitter **52** through a resistor **55**. Line **23** is coupled to base **53** by a diode **57**. The diode **57** is oriented to conduct current away from the base **53** corresponding to the direction of current flow out of base **53** during conduction of transistor **51**.

In operation when positive pulses appear on lines **23** and **37** the junction between emitter **52** and base **53** is positively biased causing the transistor **51** to conduct. The potential drop across diode **57** prevents conduction of transistor **51** in response to positive voltages on lines **23** and **37** below a minimum threshold value. Resistor **55** in conjunction with diode **57** produces a clamping action which standardizes the pulse amplitude in winding **61**, thereby eliminating variations in pulse amplitude due to losses in lines **23** and **37**.

When the transistor **51** conducts, current flows through a primary coil **61** of a transformer **62** thereby inducing a current flow in a secondary winding **63**. The dots placed near the ends of windings **61** and **63** indicate the direction of current flow within the transformer **62**. When current flows into the end of the coil **61** near the dot, current flows out of the coil **63** at the end near the dot. A diode **65** is connected in series with the secondary winding **63** and oriented so that the forward direction of current flow corresponds to the direction of current flow through transistor **51** into coil **61**. A damping resistor **66** is connected across the secondary winding **63**. The function of the resistor **66** is described below in connection with the cut-off operation of the transformer **62**. Another resistor **67** is connected across a pair of output terminals **68** and **69**. The resistor **67** is used to provide the terminating load on the receiver **18** and may be adjusted in accordance with the type of utilization device, not shown, connected to output terminals **68** and **69**.

When the transistor **51** cuts off the flux developed in transformer **62** collapses reversing the voltage across the windings **61** and **63**. During the collapse of the flux in transformer **62** the collector **54** is at a more negative

potential than the base **53**, thereby reverse biasing the junction therebetween. In this state a high impedance is presented by the transistor **51** resisting the backward flow of current through to line **37**. Further, the collapse of the flux in winding **61** occurs rapidly due to the high impedance presented by transistor **51**.

This may be seen readily by considering the time constant of the circuit which is given by L/R, where L is the magnetizing inductance of transformer **62** and R is the resistance presented by transistor **51** in parallel with the resistance reflected to primary winding **61**. Since the resistance presented by transistor **51** is large when the junction between collector **54** and base **53** is reverse biased, the time constant is reduced. Therefore the decay of the flux in winding **61** may be made to occur very rapidly.

At the same time that the flux collapses in primary winding **61** in response to the cut-off of transistor **51**, the flux collapses in secondary winding **63**. This generates a voltage opposite to that provided during the conduction of transistor **51**. The voltage generated by the collapse of flux in coil **63** reverse biases diode **65** dropping the voltage between output terminals **68** and **69**. Resistor **66** is provided to dissipate the energy stored in coil **63**. By making resistor **66** large, the time constant of the circuit including winding **63** can be made very short in duration thereby causing the rapid disspiation of the flux in winding **63**.

When the transistor **51** begins conducting the buildup of flux in coils **61** and **63** occurs very rapidly since the resistance presented by transistor **51** during conductivity is very small and the resistance of the diode **65** biased in the forward direction is also small. Therefore the circuit is capable of rapidly turning on and turning off permitting the data pulses to be spaced very close together.

Also included in receiver **18** is a transistor **81** having an emitter **82**, base **83** and collector **84**. A resistor **85** couples the emitter **82** to line **23**. A diode **87** couples the base **83** to line **37**. A primary winding **91** of a transformer **92** is coupled across the collector **84** to the base **83** through diode **87**. A secondary winding **93** has a damping resistor **94** connected directly thereacross, and a diode **95** connected in series therewith. A load resistor **97** is connected across a pair of output terminals **98** and **99**.

When negative signals appear at lines **23** and **37**, i.e., **37** is more negative than **23**, transistor **81** conducts. Current flow into the end of winding **91** near the dot creates a current flow out of the end of winding **93** near the dot. The forward direction of current flow through diode **95** corresponds to the direction of current flow through transistor **81**. The collapse of flux in windings **91** and **93** reverse biases the collector-base junction of transistor **81** and reverse biases diode **95**. Transformer **92** recovers rapidly in the same manner as transformer **62** described above. However the secondary winding **93** is reversed with respect to the primary winding **91** so that the negative signals on primary winding **91** are inverted and produce positive pulses at the output terminals **98** and **99**.

Due to the blocking of spurious negative signals caused by the collapse of flux in winding **61**, these signals do not sneak back into lines **23** and **37** where they would cause transistor **81** to conduct. In the same manner spurious signals from winding **91** do not cause transistor **51** to conduct producing an erroneous output.

The voltage between terminals **68** and **69** is designated V_{OA} and represented by a waveform **101** in FIG. 2. The waveform **101** is identical to waveform **25** in FIG. 2. The voltage between output terminals **98** and **99** is designated V_{OB} and illustrated by a waveform **102** in FIG. 2. The waveform **102** is the inverted form of waveform **29**. A line **103** is shown connected between the shield **47** and output terminals **69** and **99**. The line **103** is used to reference the output signals V_{OA} and V_{OB} with respect to ground **49**. Although the output signals are referenced to ground at this point, no "common mode" noise is injected into the output signals by such an interconnection. The transformers **62** and **92** isolate the output from the "common mode" noise on lines **23** and **37** thereby preventing the appearance of this signal at the output terminals.

Although receiver **18** employs PNP type transistors **51** and **81**, NPN type transistors could be substituted with a rearrangement of the diodes, **57**, **87**, **65**, and **95**. Further, either one of the transistors **51** or **81** could be replaced with an NPN type transistor. In this latter modification the connection of lines **23** and **37** to the transistor would have to be altered. For example if transistor **81** were replaced with an NPN type transistor, then line **37** would be coupled to the emitter **82** and line **37** would be coupled to the base **83** through diode **87**. The connections to transistor **51** would remain the same.

In accordance with another modification of the present invention the diodes **57** and **87** could be replaced with a linear impedance, such as a resistor, in which case resistors **55** and **85** would be eliminated.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for eliminating "common mode" noise from a train of data pulses appearing as the difference in voltage between a first and a second input line, said pulses containing a substantial DC component, comprising:

a transistor having a base, an emitter and a collector electrode;

a first diode connected in series with said base and oriented to permit current flow in the direction causing conduction of said transistor;

a transformer having a primary winding and a secondary winding, said primary winding being connected across said first diode and said collector electrode;

means coupling said first input line to said emitter electrode and coupling the second input line to the connection between said first diode and said primary winding; and

a second diode connected in series with said secondary winding and oriented to pass pulses of a polarity type corresponding to the type passed to the primary winding of said transformer.

2. Apparatus as defined in claim **1** further characterized by the addition of a damping resistor connected across said secondary winding.

3. Apparatus for separating bi-polar pulses appearing as the difference in voltage between a first and a second input line, comprising:

a first and a second transistor each having a base, an emitter, and a collector electrode;

a first and a second transformer, said first transformer being coupled across the base and collector electrodes of said first transistor, and said second transformer being coupled across the base and collector electrodes of said second transistor; and

means coupling said first input line to the emitter electrode of said first transistor and the base electrode of said second transistor, and coupling the second input line to the base electrode of said first transistor and the emitter electrode of said second transistor.

4. Apparatus for separating bi-polar pulses appearing as the difference in voltage on a first and a second input line, comprising:

a first and a second transistor each having a base, an emitter, and a collector electrode;

a first and a second transformer each having a primary and a secondary winding, the primary winding of said first transformer being coupled across the base and collector electrodes of said first transistor, and the primary windings of said second transformer being connected across the base and collector electrodes of said second transistor;

means coupling the first line to the emitter of said first

transistor and the base of said second transistor, and coupling said second input line to the base of said first transistor and the emitter of said second transistor; and

a first and a second unilateral conducting means connected to the secondary windings of said first and second transformers respectively, the orientation of said first and second unilateral conducting means being selected to permit current flow in response to the conduction of said first and second transistors respectively.

5. Apparatus as defined in claim 4 wherein said first and second unilateral conducting means are diodes connected in series with the secondary windings of said first and second transformers respectively.

6. Apparatus as defined in claim 5 further characterized by the addition of a first and second damping resistor connected directly across the secondary windings of said first and second transformers respectively.

7. Apparatus as defined in claim 6 wherein said base electrodes include unilateral conducting means permitting current flow only in the direction causing conduction of the associated transistor.

8. Apparatus for separating bi-polar pulses on a pair of input lines, comprising:

pair of transformers each having a primary and secondary winding, a first side of each of said primary windings being connected to opposite ones of said input lines,

a pair of transistors each having a base, an emitter and a collector electrode,

means connecting said transistors in series, emitter to collector, between opposite ones of said input lines and the second side of each of said primary windings, and

biasing means connected between the base of each transistor and the other input line from that to which each transistor is connected whereby each transistor will be rendered conductive by input pulses of opposite polarity types.

9. Apparatus as set forth in claim 8 wherein said biasing means comprises a separate diode connected between the base of each transistor and the opposite side of the input lines.

10. Apparatus as set forth in claim 9 including a resistor connected in series between each of said transistors and said input lines.

11. Apparatus as set forth in claim 8 including unidirectional current carrying means connected in series with each of said secondary windings whereby only pulses of a desired polarity will pass therethrough.

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THOMAS A. ROBINSON, *Examiner.*